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Predator Diversity of Mayflies from Kolhapur District, India

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ABSTRACT

Mayflies (Ephemeroptera) are the most primitive and ancient insect group globally; there are about 3000 species of mayflies belonging to 400 genera and 42 families. Out of which 390 species belonging to 84 genera and 20 families occur in the oriental region. From India, 124 species of mayflies have been recorded under 46 genera and 12 families. Adult mayflies are terrestrial and immature forms are aquatic and called naids (nymphs). Mayflies are good source for food for various animal groups such as Insects, Platyhelminthes, Spiders, Pisces, Amphibians and Aves. Therefore, biodiversity of predatory species of mayflies have been studied as nutrition affect the life cycle, survival, fecundity, sex ratio, etc. A list of 40 predatory species of above said groups has been reported from rivers Panchganga, Krishna, Warna, Bhogavati, Kumbhi, Kasari, and Saraswati of Kolhapur district.

Key words – Predator diversity, Mayflies, Rivers, Kolhapur district

INTRODUCTION

The nutritive value of food significantly affects the life history characteristics of a variety of aquatic insect species (Sweenery, 1984). Several studies have focused on food as an experimental variable and the interaction between temperature and food in aquatic ecosystem (Anderson & Cummins, 1979). For aquatic detritivores, studies of food quality have largely involved rearing larvae for various length of time on different species of deciduous leaves (Wallace *et al.,* 1970). Leaf species often differ from one another in terms of biochemical composition and associated microflora. Larval feeding and growth rates are vary significantly with the species of leaf provided as food (Cummins *et al.,* 1973).

Herbivory is an important factor regulating the biomass and community structure in streams (Feminells and Howkins, 1995). Stream food webs rely primarily on two food sources: autochthonous primary production within the stream and autochthonous organic matter transferred to the stream as leaf litter, woody debris and dissolved organic carbon. Autochthonous algae are more important than autochthonous organic matters to stream consumers (March and Pringle 2003) since they are the main energy source in some headwater streams (Mantel *et al.,* 2004, Lau *et al.,* 2008, 2009, Li and Dudgeon 2008). Considering the fact that Kolhapur district abounds in tanks, ponds, small lake reservoirs and wetlands of various sizes, the diversity of mayflies and their predators will add great relevance in sustainable development of this region. Mayflies (Insecta: Ephemeroptera) are pollution indicators. Therefore, it is necessary to investigate their mortality factors in terms of their predation.

Review of literature indicates that mayflies have been studied by several workers (Fladung ,1924; Bodenheimer,1951; Martof & Scott,1957; Wallance *et al.,*1970; Cummins *et al.,*1973; Downes, 1978; Brittain, 1978; Anderson & Cummins,1979; Reinecke *et al.,* 1980; Soluk & Clifford, 1984; Sweeney, 1984; Bart & Holzenthal, 1985; Nost ,1985; Gibbs & Mingo,1986; Giller, 1986; Scrimgeour & Winterbourn, 1987; Bergeron *et al.,*1988; Dudgeon ,1989; Harries ,1990; Ormerod & Tyler,1991; Kjellberg,1992; Rabeni, 1992; Gupta *et al.,*1993; Caira *et al.,*1995; Castien & Gosalbez, 1995; March & Pringle, 2003; Mantel *et al.,* 2004; Lau *et al.,*2008, 2009; Li & Dudgeon, 2008; Sathe, 2014, 2015), Kamble & Sathe, 2015, 2016; Sathe & Patil, 2016) from the review of their predation and seasonal abundance from different part of the world.

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MATERIALS AND METHODS

Study site:

Diversity of mayflies specially their nymph and adults and their predators both from vertebrates and invertebrates have been studied from rivers in Kolhapur district. (Lat. 16^0 41' 44 N, Long 74^0 13' 54 E Alt. 184 F, 543msl). Kolhapur district (Fig.1) receives an annual rainfall of about 1138.5 mm, most of which occurs during June to October.

Figure-1. Rainfall of Kolhapur district

Collections were made from marginal weed beds of rivers beside, some predators have been dissected which were collected from various rivers viz,

I. Krishna - Shirol (Alt-1732 F, 527msl, Lat- 16^o 61 N, Long- 74^o 36 E),
II. Panchganga – Karveer (Alt-1867 F, 543msl, Lat- 16^o 41N, Long-74^o13 E),
III. Warna - Hatkangale (Alt -1939 F, 591msl, Lat-16^o 61' N, Long- 74^o 35 E),
IV. iv)Kasari - Panhala (Alt-2903 F, 845msl, Lat- 16^o 82 N, Long- 74^o 12 E),
V. Kasari - Shahuwadi (Alt-1903 F, 580msl, Lat- 16^o 85 N, Long- 73^o 90 E),
VI. vi)Bhogavati - Radhanagri (Alt -2034 F, 619msl, Lat- 16^o 24.50N, Long- 74^o 59.52 E),
VII. vii) Kumbhi - Gaganbavda (3177 F, 900msl, Lat- 16^o 69' N, Long- 74^o 107 E),
VIII. viii) Sarasvati - Gaganbavda (3177 F, 900msl, Lat- 16^o 69' N, Long- 74^o 107 E) and observations have been made on the availability of body parts of mayflies in the gut of predators. The selection of study spots was based on variations in rainfall and altitute.

Experimental set up:

Air and water temperature readings taken with a mercury bulb thermometer at the time of collection of water and insect samples. Nymphs of Mayflies species and the other aquatic predatory insects collected by dragging a 25 x 25 cm net of 200 μm mesh through a 2m long section of the weed bed and density finally expressed as numbers per unit sampling effort. Three replicate samples collected at fortnightly interval. Nymphs preserved in the field, in 6% formalin to prevent possible digestion of food materials and sorted in the laboratory under a dissecting binocular microscope. Body length (excluding antenna and cerci) and head width measured with a calibrated ocular micrometer. Mayflies emergence data were obtained by collecting submagines from the underside of leaves of the lake side vegetation and by rearing nymphs in the laboratory. The foregut contents of predatory nymphs/ larvae/ adult pooled and mixed with water of known volume in a tube. This suspension was then vigorously agitated and 1 ml subsample transferred to a small counting cell fitted on a glass slide and examined under a microscope equipped with a squared ocular grid.

Five to ten such subsamples examined. The number of diatoms, desmids, flagellates, and cells of filamentous algae in each subsample as well as the number of squares in the grid occupied by detritus and mineral particles counted. (Shapas & Hisenhoff 976). The predators identified as feeding on mayflies by gut or fecal analysis or by direct observation of feeding.

RESULTS

Diversity of Mayflies and their predators recorded in table-1 and figs- 1 to 11 indicated that a total no. of 40 species of predators from invertebrates and vertebrates were prevalent in Kolhapur region. While, the mayflies predated were from more than ten species (table-1). The most abundant of mayflies recorded were *Baetis* spp, *Leptophelebia* sp., *Heptanigids* and *Indialis* sp. Desmids and filamentous green algae were abundant during May to October, especially July to September while, detritus gained importance food during November to March. Flagellates were abundant during November to April. Diatoms were found in the gut almost throughout the year.

Population size of mayflies was relatively small during December to February 2015-2016. Thereafter, from October onward, density built up steadily to reach a peak in May to June after which it declined, although a sizeable population persisted in June. Reduced density in July to October was most likely to have been caused by low temperature rains and flooding in Kolhapur District.

DISCUSSION

According to Gibbs and Mingo (1986), some mayflies are predators of other mayflies. *Siphlonisca aerodromia* nymph begin their lives as small detritivores but these agile, rapid swimmers became more carnivorous as the age, feeding on the likes of *Siphlonurus, Leptophelebia* and *Ephemerella.* The sand dwelling heptageniid, *Pseudiron centralis*, prefered chironomids as food, 5%

Table-1. Predators of Mayflies from Kolhapur District

Sr. No	Predators	Mayflies	Prey stage attacked	Distribution
	Invertebrates :			
	Platyheleminthes :			
1.	*Tricladida* sp.	*Baetis* sp.	Nymph	AJR, RDR
2.	*Dugecia* sp.	*Baetis* sp.	Nymph	SR, KR, HTK
	Arthropoda :			
	Ephemeroptera :			
3.	*Ephemerella* sp.	*Indialis badia*	Nymph	HTK, KR
4	*Baetis* sp.	*Indialis* badia	Nymph	HTK
5	Odonata :			
6	*Libellula depressa*	*Leptophelebia* sp.	Nymph, Adult	KR, RDR
7	*Anex* sp.	*Ephemerella* sp.	Nymph, Adult	GGD
8	*Pantala* sp.	*Indialis badia*	Nymph, Adult	KR, HTK
9	*Crocothemis survilia*	*Caenis*	Nymph, Adult	PNH
10	*Ischnura* sp.	*Leptophelebia* sp.	Nymph, Adult	PNH
11	*Ceriagrion* sp.	*Baetis* sp.	Nymph, Adult	SHW
12	*Lestes* sp.	*Baetis* sp	Nymph, Adult	HTK
	Penueus indicus	*Caenis*	Nymph	KR
13	Hemiptera :			
14	*Ranatra elongata*	*Indialis badia*	Nymph	KR, GGB, RDR
15	Scorpion bug	*Baetis* sp.	Nymph	PNH
	Notonecta sp.	*Leptophelebia* sp.	Nymph	
	Acarina : Spiders			
16	Lycosa sp.	Heptaginids	Adult	KR,GGB
17	Hippasa sp.	Heptaginids	Adult	RDR
18	Pandosa sp.	Heptaginids	Adult	
	Vertebrates : Pisces :			
19	Poecilla reticulata	*Baetis* sp.	Nymph	SR, AJR
20	*Cyprinus* sp.	*Caenis* sp.	Nymph	GGD
21	Oreochromis	*Indialis badia*	Nymph	SR
22	*mossambica*			
23	*Gambusia affinis*	*Leptophelebia* sp.	Nymph	PNH
24	*Clarias batrochus*	*Baetis* sp.	Nymph	KR, HTK
25	*Labeo rohita*	*Indialis badia*	Nymph, Adult	SHW
	Catla catla	*Indialis badia*	Nymph	PNH
26	Amphibia :			
27	*Bufo* spp.	*Caenis* sp.	Adult	KR
28	*Rana* sp.	*Baetis* sp.	Nymph, Adult	RDR
29	*Duttaphrynus* sp.	*Indialis* sp.	Adult	SR
30	*Euphlyetis* sp.	*Indialis* sp.	Nymph, Adult	GGD
	Polypedatus sp.	*Indialis* sp.	Nymph, Adult	SR
31	Reptalia :			
32	*Salamandra* sp.	*Leptophelebia* sp.	Adult	GGB
	Euphaea decorata	*Ephemerella* sp.	Adult	SR, HTK
33	Aves :	*Baetis* sp.	Adult	KR
34	*Merops orientalis*	*Leptophelebia* sp.	Nymph, Adult	CGD,KR
	Amaurornis phoenicurus			
35	*Ardeola groyii*	*Leptophelebia* sp.	Nymph	SR
36	*Pscnonotus cafer*	*Baetis* sp.	Adult	RDR
37	Wagtail	*Indialis badia*	Adult	PNH
38	Mammalia : Chiroptera :			
39	*Pteropus giganteus*	Heptaginids	Adult	SR, KR
	Hipposideros speoris	Heptaginids	Adult	PNH
40	Primates :			
	Homo sapiens	Heptaginids	Nymph, Adult	RDR

Note – SR- Shirol, KR – Karveer, HTK – Hatkangale, PNH – Panhala, SHW – Sahuwadi, GGD – Gaganbavda, RDR – Radhanagri.

Figure-2. *Indialis Badia* Adult

Figure-3. *I. badia* Nymph

Figure-4. *Ephemerella* Nymph

Figure-5. Ischunura sp. Adult

Figure-6. Damselfly Nymph

Figure-7 *Crocothemis* Nymph

Figure-8. Ranatra sp. Adult

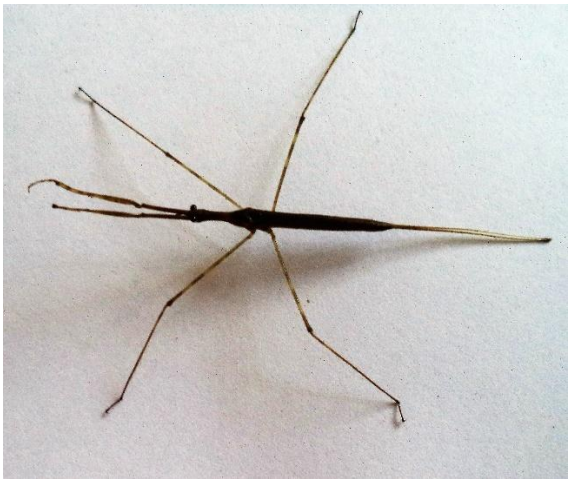

Figure-9. *Lycosa* sp.

Figure-10. *P. indicus sp*

Figure-11. Frog tadpole

of its foregut contents was composed of early instars of *Baetis, Centroptilum* and *Ephron* (Soluk and Clifford, 1984). Agnew (1962), found remains of baetid nymphs in two of seven guts in *Centroptiloides bifasclata* and *Ephemerella sp.* In the nymphs of above two species 50%, gut was fitted with *Hetagenia* nymphs (Muttkowski and smith, 1929).

Downes (1978) has observed six species of Ceratopogonids (Diptera) feeding on mayflies. The female Ceratopogonid typical entered in to the mayfly swarm and landed on the thorax for predation. Fifty species of Podagritis wasps (Hymenoptera: Sphecidae) were distributed throughout America, Australia and New Zealand as dipterivorus (Harris, 1990). Harries (1990) reported two species *P. albipes* and *P. cora* in New Zealand, were rather unusual. They made their nests almost exclusively with *Deleatidium* mayflies, female wasps wait on rocks in the stream until they encounter a *Deleatidium* nymph in the process of molting to the subimago (Harries, 1990). A muscid fly *Spilogona* sp. completed with the wasps for subimagoes emergence on the rocks in the stream. Similarly, the larvae of therevid fly *Anabarynchus* sp. burrows through the soil along the edge of the stream. When this larva encountered a provisioned nest *Podagritis,* it consumed the mayfly *Deleatidium* (Harries, 1990).

According to Dudgeon (1989) the nymph of damselfly, *Euphaea decorata* has showed preference toward the nymphs of mayflies by increase of age. The number of genera for predation was twelve and high percent of the prey consumed by small nymphs was for two genera of mayflies, while a large nymphs fed on five genera which represented 36% of the prey consumed. According to Rabeni (1992) mayflies were the larger portion of the food for young smallmouth bass, *Micropterus dotomieu* and rock bass, *Ambloplites rupestris* with still larger portion of the food for older white suckers, *Catastomus commersoni* (Chen and Harvey, 1995) and common river galaxias, *Galaxias vulgaris* (Cadwallader 1975). The change in the food preference of galaxias occurred when it moved from quiet water to riffles have a greater diversity of food items (Cadwallader 1975).

According to Caira and Orringer (1995), fishes feed predominantly on mayflies. Young freshwater stingrays, *Potamotrygon magdalenae,* feed exclusively on

mayflies. The relative frequency of mayflies in the gut of some fishes was very high; some species exhibited a wide range of preference to young small mouth bass, *Micropterus dolomieu* (Easton *et al.,* 1996), Bluegilled bully, *Gobiomorphe hubbasi*, and torrentfish, *Cheimarrichthus fosteri ,* green sandpipers, *Tringa ochropus,* green beeeater, *Merops orientalis, Chiroptera,Pterops giganteus* (Scrimgeour and Winterbourn, 1987). Salamander (Gulf coast waterdog) *Necturus beyeri,* prefered *Leptophelebia* mayflies to younger and *Stenonema* mayflies to older forms (Bart and Holzenthal, 1985). The birds, *Eurasian dipper*, *Cinclus cinclus* consumed more mayflies during the breeding season (Cormerod and Tyler, 1991) as like the black duck, *Anus rubripes* (Reinecke and Owen, 1980). Similarly, the salamander, *Leurognathus marmorata* found feeding on 10 species of Mayflies (Mart-of and Scott 1957).

The Pyrenean desman *Galemys prynaicus* (Mammalia) found feeding commonly on mayflies, about 96% of all the guts examined contained mayflies body parts (Castien and Gosalbez 1995). However, these mayflies only represented 16% of the food ingested by volume. According to Castien and Gosalbez (1995), mayflies do not account for a large volume of the food consumed. However, mayflies by small predators abundant in the stream easily captured and consumed. According to Reinecke and Owen (1980), mayflies represented 29% of the grass energy ingested in black ducks. Similarly, the green sandpiper, *Tringa ochropus* consumed 9.500 to 11.000 *Baetis* nymph per day (Ormerod and Tyler, 1988). Mayflies are also recognized as human (*Homo sapiens*) diet (Bodenheimer, 1951) described. In North Vietnam, Chiana and Japan mayflies largely consumed by humans. The people of Malawi make a paste out of Mayflies (*Caenis kungu*) and mosquito called kungu (Fladung, 1924).

Gut content analysis of nymphs by Nost (1985) showed to be herbivore- detritovore and that there was a seasonal shift in the food items found in the gut from green algae during December to April to detritus and to some extent, flagellates, during June to July. From June till around October, dense algal masts were observed to cover the *Hydrilla* strands, a microscopic examination of which revealed the predominance of *Spirogyra, Oedogonium,Closterium, Cosmarium, Staurastrum, Oscillaitoria* and *Mougeotia* (Gupta *et al.,* 1993) and these were forms which constituted a major portion of the food of nymphs during this period. Several studies reveal that algae were the food of superior quality than detritus (Cummins & Klug, 1979, Bird and Kaushik, 1984). The observations of on growth of nymphs fed algae/detritus also showed that mayflies grow and reach maturity faster on an algal diet (Gupta *et al.,* 1993). Thus, it seems probable that several factors such as a higher temperature regime, abundance of energy rich algal food and probably reduced predation pressure, were responsible for the population buildup of nymphs during March to June, although studies that are more specific would have to be conduct to understand further the role of these factors in predation.

Okedi (1992) noted that the traditional protein for some domestic African animals including fish, have declined over the years. He considered using the lakeflies as a source of protein. His analysis along with that of Bergeon *et al.,*(1988) show that these insects are high in protein, minerals, B vitamins and essential amino acids. They were also low in fat and moisture and thus contributed for long life. The insect's cakes have a high digestibility. *Povilla* occurred in huge swarms made them relatively easy to capture and to use as food. However, suitable commercial harvesting technique needs to be design. Very recently, Sathe (2015) exposed some insects as human diet including their preparation and values.

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Conflict of Interests

Authors declare that there is no conflict of interests regarding the publication of this paper.

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